METRIC EVALUATION OF PARTIALLY DISPLACED TEMPOROMANDIBULAR JOINT DISC

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SUMMARY – The objective was to determine the quantitative relationship between the condyle and disc position in the glenoid fossa between two different slices of the same temporomandibular joints (TMJs) with partial anterior disc displacement (DD). The study was conducted on 40 patients with DD of TMJs (mean age, 35.5 years). The clinical diagnosis of DD was confirmed by magnetic resonance imaging. Joints from the patient groups were analyzed according to the laterality and depending on disc displacement (a total of 80 joints). Comparison was made between two different slices of 9 joints with partial DD with reduction: partial DD was analyzed in the representative centrolateral or centromedial parasagittal slice of the TMJ (TMJ partial DD – slice DD). The contralateral slice of the same joint was without DD (TMJ partial DD – slice NDD). The analysis also included 34 healthy joints without DD (TMJ NDD) of the same patients. The position of the condyle and disc was calculated using the Kurita *et al*. method on the parasagittal view of the TMJ. A statistically significant difference was recorded for different slices of the same TMJs with partial DD (TMJ partial DD – slice DD and TMJ partial DD – slice NDD) ($p<0.01$), but no difference was found in condyle positions depending on the existence of partial DD ($p>0.05$). The compared values between slice TMJ partial DD – slice NDD with the group of TMJ NDD showed no significant difference in either disc position or condyle position ($p>0.05$). There were differences of disc position in various slices of the same joint with visually confirmed partial DD. The dorsocranial condyle position could not indicate partial anterior DD.

Key words: *Magnetic resonance imaging; Temporomandibular joint disc – pathology; Temporomandibular joint disorders – pathology; Dislocations – pathology*

Introduction

Temporomandibular disorders (TMDs) is a collective term that includes a number of clinical conditions and diagnosis of functional disorders involving the masticatory muscles, the temporomandibular joint (TMJ) or both with the associated orofacial structures. The two major clinical features of functional TMJ problems are preauricular or auricular pain, noises (clicking and crepitation), and oral dysfunction (limited mouth opening). TMJ disorder is usually present as a disruption of the normal condyle-disc movement. This disc disorder is the most common TMD diagnosis under the name anterior disc displacement (DD). Another common diagnosis is osteoarthritis, related to roughness of the articular surfaces[1-4].

Magnetic resonance imaging (MRI) has been widely accepted as a 'gold standard' tool for diagnosing DD, which is the most common type of TMJ

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disorders. A cross-sectional image of the TMJ in the individually angulated or parasagittal plane enables clear view of the glenoid fossa, disc and condyle as the most important parameter of TMJ visual analysis[5].

There is slight uncertainty in defining the term 'partial DD' when it is observed in closed mouth position. Many authors differentiate between partial and complete anterior DD (which is evaluated on the basis of three different parasagittal slices of the same joint) according to radiologic and/or anatomic analyses of the TMJ, as well as on the basis of clinical diagnosis[6-9]. However, numerous studies based on MRI and the Diagnostic Criteria (DC) for TMD Axis I diagnostic system do not mention the diagnosis of partial DD[10-13]. Apart from the metric evaluation of anterior DD in degrees according to the 12 o'clock method[14], there are no studies on the quantitative evaluation of the position, that is, on the DD in joints with partial DD.

The aim of the study was to determine the relationship between the position of the disc and condyle head in the glenoid fossa between two different parasagittal slices (slice with DD and slice without DD) of the same TMJs with partial anterior DD. Slices with DD of partially displaced TMJs were compared with physiological disc position (without DD) differentiated from the same sample of patients with TMJ disorder in contralateral TMJs.

Materials and Methods

The study was conducted on 40 patients with DD of TMJs (aged 15-71, mean 35.5 years; 1:3 men to women ratio), who were collected consecutively because they sought help due to the following clinical symptoms of TMJ disorders: painful TMJ and clicking and/or limited mouth opening. The clinical diagnosis of various DDs (partial DD with reduction, total DD with and without reduction) was established using manual functional analysis (MFA)[9,15]. All patients were examined by MRI, which was used to confirm and establish definitive diagnosis of DD. All patients willingly agreed and gave their written consent to participate in the study which was approved by the Ethics Committee of the School of Dental Medicine.

MRI was performed with a 1 T Harmony scanner (Siemens, Erlangen, Germany; with the following spin-echo-sequent parameters: T1 weighted image TR/TE 450/12, T2 weighted image TR 3000/TE 66, field of view of 160x160, matrix of 256x192 and 3-mm slice), and with a 1.5T Avanto scanner (Siemens, Erlangen, Germany; with the following spin-echo-sequent parameters: T1 weighted image TR/TE 410/9.4, T2 weighted image TR 460/TE 15, field of view of 180x180, matrix of 410x512 and 2-mm slice).

MR images in the parasagittal plane were obtained in the closed- and open-mouth position. The angle of the parasagittal imaging was individually determined by the angle shown on the individual angulated slices of the axial and coronal slice. The open mouth position was fixed with an inter-incisal individual fixator using the Optosil® P plus (Heraeus Kulzer, Hanau, Germany).

The disc physiological position in closed-mouth position was defined according to the placement of its inter-medial zone between the articular eminence and the shortest distance of the bone contours of the condyle ventrocranial part in the parasagittal plane in the closed mouth position according to Orsini *et al.*[16] and Bumann and Lotzmann[9].

Qualitative analysis was performed for each TMJ to examine the three representative slices (centrolateral, central and centromedial) in the parasagittal slice on the basis of which partial or complete DD was determined in closed mouth position. Complete DD means that the disc is displaced in all slices. Partial DD is confirmed if the disc is in the physiological position in one (centrolateral or centromedial) slice,

Table 1. Distribution of disc positions in TMJs and symptomatic TMJs of all patients

Disc position (n, %)	Partial DD	DD with reduction	DD without reduction	Normal	Total
All TMJs	9 (11.25%)	15 (18.75%)	21 (26.25%)	35 (43.75%)	80 (100%)
Painful TMJs	9 (20.93%)	15 (34.88)	19 (44.19%)	–	43 (100%)

n = number of joints; DD = disc displacement; TMJ = temporomandibular joint

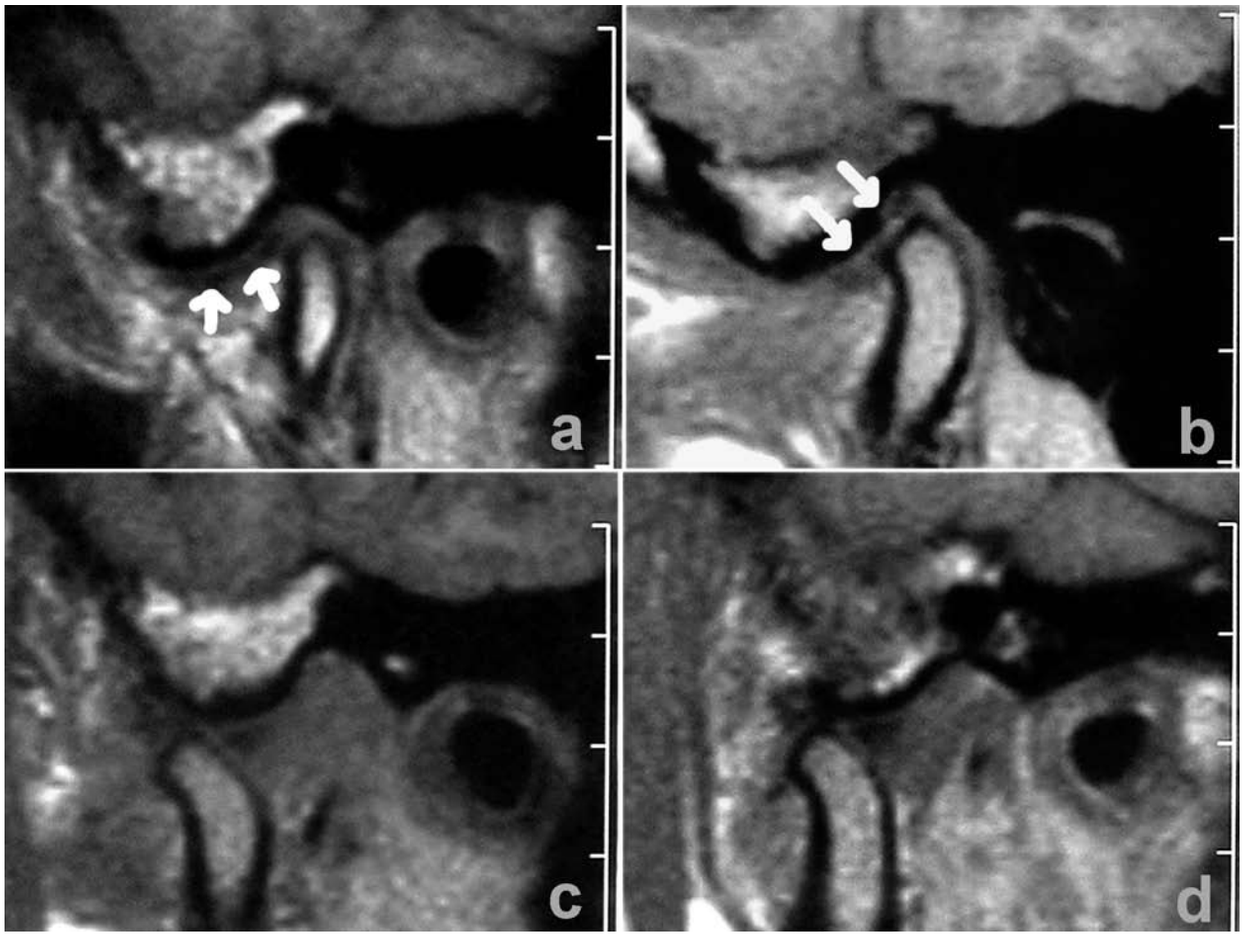


Fig. 1. Magnetic resonance imaging (1 T scanner) of temporomandibular joint with disc displacement with partial reduction. The disc is displaced in one parasagittal slice (a) and normally positioned in another slice (b). The arrows show disc position. The slices show normal disc position in the open mouth images (c, d).

and displaced in the opposite slice (centrolateral or centromedial) in the same TMJ. Partial DD with reduction was found in the representative centrolateral or centromedial parasagittal slice of 9 TMJs (Figs. 1 and 2) in closed-mouth position. Other categories of TMJs, i.e. complete (n=15) reducing DD and complete (n=19) nonreducing DD, were not included in this study (Table 1).

Qualitative analysis was used to compare the difference between the calculated disc and condyle position related to the following groups: at first, two different slices of the same TMJs with partial DD were compared: slice without DD ('TMJ partial DD – slice NDD') and slice with DD ('TMJ partial DD – slice DD'). Secondly, 34 healthy joints without DD ('TMJ NDD') of the same patient group from this study (regardless of the existence of partial or complete DD in the contralateral joint) served as a control group of TMJs compared with the 'TMJ partial DD – slice DD' group. However, one joint without DD and with osteoarthritis and two joints with asymptomatic DD were excluded.

Relative position of the condyle and disc was calculated using the method described by Kurita *et al*.[17] (Fig. 3). A line was drawn on the tangent between the lowest part of the articular eminence (T) and the highest edge of the external auditory canal (P), perpendicular to the tangent, touching the back edge of the disc, and their intersection was marked as point D. Another perpendicular, touching the back edge of the condyle was also drawn and marked as point C. A lower value indicates a more anterior condyle or disc

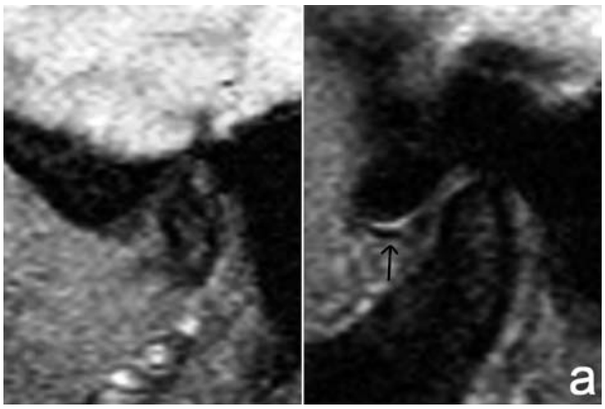


Fig. 2. Magnetic resonance imaging (1.5 T scanner) of temporomandibular joint in the closed mouth position (a) with partially displaced disc with reduction (arrow shows displaced disc). The slices show normal disc position in the open mouth images (b).

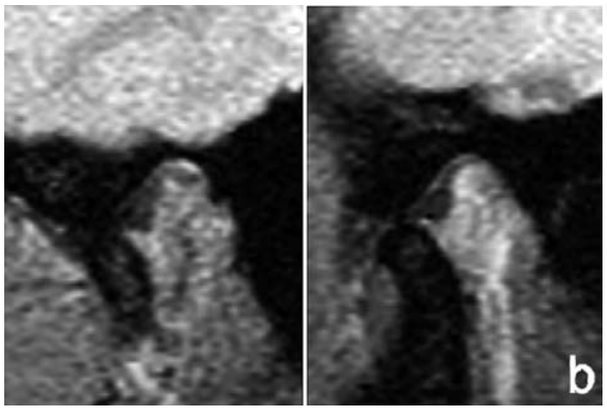
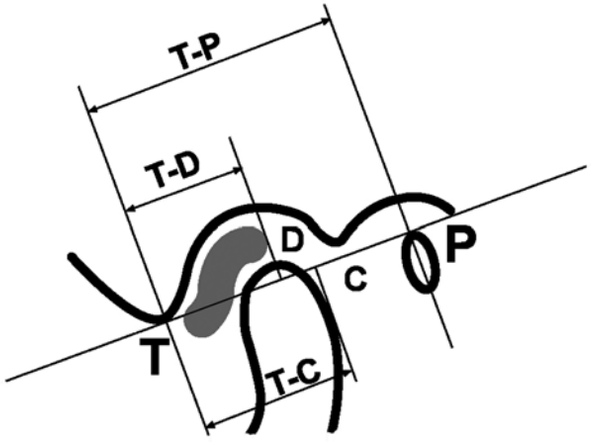


Fig. 3. Measuring the position of the disc and condyles in the parasagittal plane by Kurita et al.[17].



position. Absolute values (TP, TC and TD) were measured using ISSA (ISSA Network Station Version 3.1, VAMSTEC® d.o.o. 1994-2013, Zagreb). Millimeter values to one decimal place were calculated based on the measurement scale shown on MR images. The disc and condyle positions were calculated as TC/TP and TD/TP and expressed in one-hundredth of distance between points T and P.

Kruskal-Wallis test and Wilcoxon paired test were used. On data analysis (performed by STATISTICA software), the left and right TMJs of the same patient were presented as two entities. The measured values of metric evaluation were displayed by means of a box-and-whisker plot data display (the marked median encompassed the values between the 25%- to

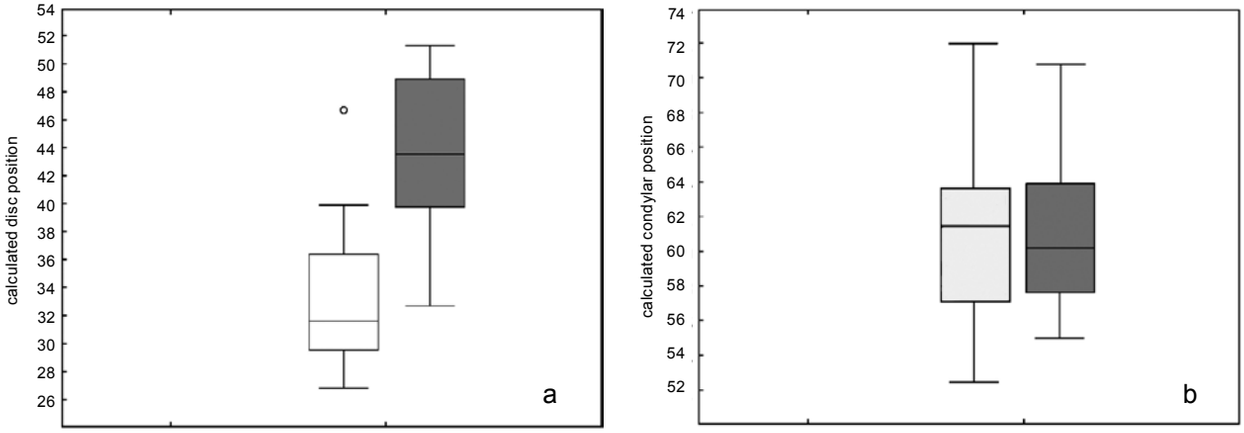


Fig. 4. The calculated disc (a) and condylar (b) positions comparison between the slices with disc displacement (DD) (left) and without DD (right) of the same TMJs with the diagnosis of partial DD (n_{joints}=9).

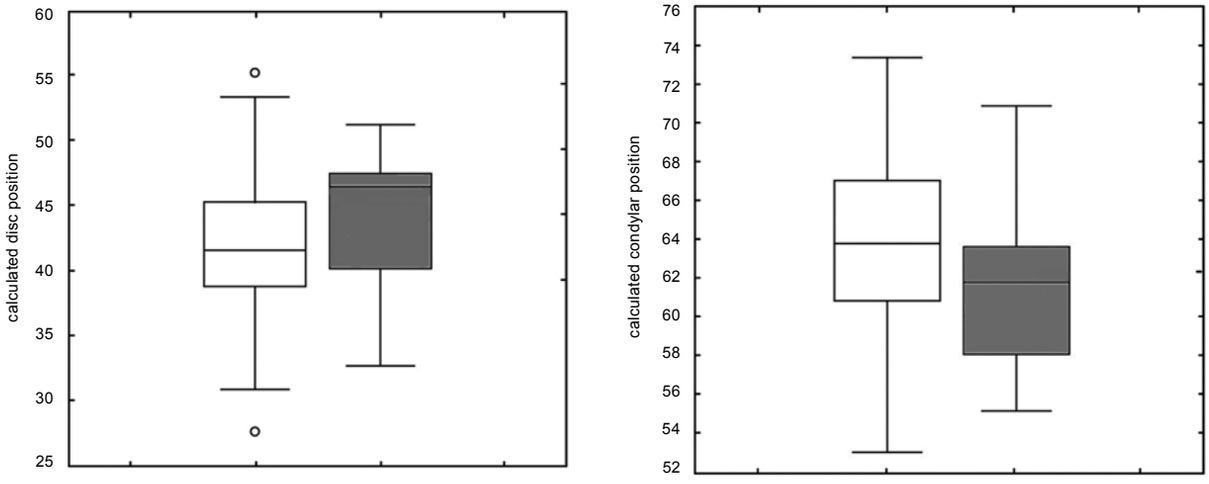


Fig. 5. The calculated disc (a) and condylar (b) positions comparison between partial reduced temporomandibular joints (TMJs) – slice without disc displacement (DD) (left; (n_{joints}=9) and healthy TMJ without DD of the same patient (right; n_{joints}=34).

75%-quartile; all the measured values except for the outliers were shown within the whisker limits). Differences were considered statistically significant at values of 0.05 and 0.01.

The reliability of MRI assessment was evaluated independently of the patient's clinical signs on MRI images on the basis of two researchers' (D.Z., radiologist and T.B., dentist) inspection and the Kappa index of reliability was between 0.8 and 1.0. The reliability of the measurements for metrical analysis was measured on 12 patients twice using the same MRIs of both joints (24 measurements in all). The method error values according to Dahlberg for all measured distances were between 0.10 and 0.07[18].

Results

There was a statistically significant difference between the position of the disc in slices 'TMJ partial DD – slice NDD' and 'TMJ partial DD – slice NDD' in the same TMJs with partial DD (Wilcoxon paired test: z=2.934; p=0.003) (Fig. 4a). In the same group of joints with partial DD, there was no difference in condyle positions (dorsocranial displacement) depending on the existence of slice with DD (Wilcoxon paired test: z=1.378; p=0.168) (Fig. 4b).

The following groups of patient joints were also compared and measured: 'TMJ partial DD – slice NDD' of joints with partial DD and healthy joints 'TMJ NDD' of other patients (with total DD in the contralateral TMJ), which showed no significant difference in either disc position (Kruskal-Wallis test KW (1.43) =0.514; p=0.474) (Fig. 5a) or in condyle (Kruskal-Wallis test KW (1.43) =2.140; p=0.144) (Fig. 5b).

Discussion

Although MFA as a method of manual medicine and physiatric treatment was presented in the early 1990s[9], this classification of tissue-specific diagnoses has not been regularly used in the diagnosis of patients with TMDs. The existing RDC/TMD system requires revision and implementation of manual diagnostic tests[9,19-21]. On the other hand, the useful possibility of clinical diagnosing partial DD using MFA was very rarely used compared to axiography and TMJ analysis of several parasagittal slices on MRI. In a recent review of topics regarding DD, Manfredini *et al.*[22] only partially mention other authors who also stressed the diagnosis of partial DD in their studies.

Westesson *et al.*[6] noted that the diagnostic limitation of arthrotomographic study of TMJ was visualization of disc position or DD in one sagittal slice only. Contrary to them, partial DD can be visible on more than one slice of TMJ. There are also some difficulties in MRI diagnostics of TMJ disc: physiological position of the disc is difficult to determine in some cases

in the intra-articular area with the same low signal as the cortical bone. Anteriorly displaced disc is situated around tissues with high signal, which enables easier detection in the relative small joint such as TMJ.

Larheim *et al.*[7] found partial DD in 22.6% of patient joints and in 21.8% of asymptomatic volunteer joints. Tominaga *et al.*[8] studied TMJs of healthy volunteers in closed mouth position only. The predominant diagnosis of partial DD remained during the follow up in 13.6% of joints, normally positioned disc partly moved anteriorly in 20.5%, and only one (2.3%) joint with a normally positioned disc became a total anteriorly displaced disc. In our study, partial DD was found in 20.9% of 43 joints of patients who were diagnosed with any form of DD, i.e. in 15% of left and 7.5% of right TMJs out of all (n=80) joints of patients with DD[19]. Foucart *et al.*[23] report on the following types of TMJ internal derangement found on MRI: anterior disc displacements without reduction (52%), anterior disc displacements with reduction (26%), partial anterior disc displacement (11%), pure sideways displacements (5%) and stuck discs (4%).

The term 'partial DD' is ambiguously used to determine the variations of anterior DD in visual analysis. In a recent study, Maizlin *et al.*[24] used the 12 o'clock position to determine disc displacement (DD), using the terms 'mild' and 'significant' disc displacement without differentiation in terms of partial DD. Mild DD (displacement between 10 and 11 o'clock) was more associated with reducible DD. On the other hand, in a recent study, Giraudeau *et al.*[25] consider a disc position with a tendency to anterior displacement as partial DD, which creates uncertainty on comparison, whereas other authors[6-8,12] do not even mention this type of displacement.

Using the 12 o'clock method, Rammelsberg[14] succeeded to quantitatively differentiate partial and total DD using more than one parasagittal slice of the same joint, wherein partial DD occurred in 66% of joints with reciprocal clicking. Furthermore, Rammelsberg *et al.*[26] found that condyle position was more posteriorly dislocated in the glenoid fossa if the patient had bilateral DD with reduction. In joints with DD without reduction, the condyle is positioned centrally in the fossa. Variability of the condyle position in the fossa was demonstrated in patients with unilateral DD. The relation between condyle positions (their dorsocranial displacement) in joints with anterior DD is not completely elucidated; according to Kurita *et al.*[17], the condyle is more posteriorly displaced at slight DD; contrary to them, DD without reduction is associated with more concentric position of the condyle. Alexander *et al.*[27] have reported that there was no prediction and significant association between the condyle position and DD of TMJ and that it does not prove the relationship between them. Incesu *et al.*[28] were in favor of DD detection according to the excentrically, that is, dorsocranially displaced condyle, even on the basis of x-ray TMJ diagnostics. Our study showed no change in condyle position in several slices of the same joint regardless of the existence of partial DD. The disc is a flexible structure and may take various positions (physiological or partially displaced only) in the sagittal plane, and an unchanged position of the condyle in different slices of the same joint is to be expected since it is a rigid, osseous structure whose position is partially determined by dental occlusion. In our study, there was no difference in condyle position of joints with or without DD.

In the intra-articular analysis, the anterior DD does not have to exist in all slices of the parasagittal plane (anterolateral or anteromedial) of the same joint in closed mouth position. Differential diagnosis should consider fibrozation of the posterior edge of the disc, that is, pseudodisc creation. Also, visual detection of anterior DD depends on the angle of the condylar pathway, which means that in a steep pathway the physiologically positioned disc could be characterized as anteriorly displaced[9,16]. On the other hand, analysis of only one mediosagittal slice creates uncertainty in the detection of pathological disc position (that is, of the displaced disc), which lowers the value of MRI as the gold standard, and can also have legal repercussions in the evaluation of MRI and clinical signs and symptoms of TMJ disorders[21,29]. Ahmad *et al.*[30] introduced a new category of intermediate DD, in cases when the pars intermediate zone of the disc is displaced, and the posterior part of the disc is situated superiorly to the condyle. This echoes the previous definitions of partial DD (according to Giraudeau *et al.*[25]). However, Bumann and Lotzmann[9] believe that as long as the disc with its posterior part is on the condyle, it is in the physiological position, and TMJ

analysis has to encompass all three parasagittal slices, which was the methodology of our study.

A recent proposal for revision of the RDC/TMDs diagnostic system suggests that in Group II Disc Displacements the revised Axis I diagnostic algorithms be supplemented with the use of MRI and CT imaging, respectively, but does not include the diagnosis of partial DD or clinical criteria for such a type of displacement[30,31]. Without supplementing clinical diagnosis with techniques such as MFA, it is not possible to differentiate between partial and total DD. The reliability of MFA in diagnosing particular clinical entities of partial DD in patients with MRI findings was demonstrated in 70% of joints[9,20,21]. In studies by other authors, the need of evaluating the inter- and intra-observer agreement is stressed, wherein the greatest matching was achieved for anterior DD without reduction. It should be pointed out that anterior DD allows for better visual differentiating of cortical bone MRI signal from the cartilaginous structure of the disc, which can be difficult in the small intra-articular space in physiological disc position. In conclusion, the study confirmed significant differences of disc position in different parts of the same TMJs with partial DD. Partial DD can only be determined by analyzing several parasagittal slices, which was confirmed by quantitative analysis in this study. Insufficient diagnostics is based on only one parasagittal slice of the TMJ image, which can reduce the effectiveness of MRI as the gold standard in DD of TMJ. The dorsocranial condyle head position is not expected to indicate partial DD, which was compared with TMJs without DD. There was no difference in physiological disc position in joints without DD ('TMJ NDD') and physiological disc position in the group of 'TMJ partial DD – slice NDD' joints.

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Sažetak

METRIČKA EVALUACIJA DJELOMIČNOG POMAKA DISKA TEMPOROMANDIBULARNOG ZGLOBA

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Predmet istraživanja bio je utvrditi kvantitativni odnos između položaja kondila i diska u glenoidnoj jamici između dva različita sloja istog temporomandibularnog zgloba (TMZ-a) s djelomičnim anteriornim pomakom diska. Istraživanje je provedeno na 40 bolesnika s pomakom diska TMZ-a (prosječna dob 35,5 godina). Klinička dijagnoza pomaka diska potvrđena je magnetskom rezonancijom. Lijevi i desni zglob pojedinog pacijenta bio je predstavljen kao kao dva entiteta (ukupno 80 zglobova). Usporedba je učinjena između dva različita sloja 9 zglobova s djelomičnim pomakom diska s redukcijom: djelomični pomak diska analiziran je u reprezentativnom centrolateralnom ili centromedijalnom sloju TMZ-a ("TMZ djelomični pomak diska – sloj s pomakom"). Kontralateralni sloj istoga zgloba bio je bez pomaka diska ("TMZ djelomični pomak diska – sloj bez pomaka"). Također, analiza je uključila 34 zdrava zgloba bez pomaka diska istih bolesnika. Položaj kondila i diska izračunat je metodom po Kuriti i sur. na parasagitalnom prikazu TMZ-a. Utvrđena je statistički značajna razlika za različite slojeve istoga TMZ-a s djelomičnim pomakom diska ("TMZ djelomični pomak diska – sloj s pomakom", "TMZ djelomični pomak diska – sloj bez pomaka") ($p<0,01$), ali nije bilo razlike u položaju kondila ovisno o postojanju djelomičnog pomaka diska ($p>0,05$). Uspoređene vrijednosti između sloja "TMZ djelomični pomak diska – sloj bez pomaka" sa skupinom zdravih zglobova bez pomaka diska pokazale su da nema značajne razlike ni za položaj diska niti za položaj kondila ($p>0,05$). Postoje razlike u položaju diska u različitim slojevima istoga zgloba kod kojih je vizualno potvrđen djelomični pomak diska. Dorzokranijalni položaj kondila ne ukazuje na djelomični anteriorni pomak diska.

Ključne riječi: *Magnetska rezonancija; Temporomandibularni disk – patologija; Temporomandibularni zglob, poremećaji – patologija; Dislokacije - patologija*